

High Entropy Alloy Nanoparticles Encapsulated in Graphitised Hollow Carbon Tubes for Oxygen Reduction Electrocatalysis

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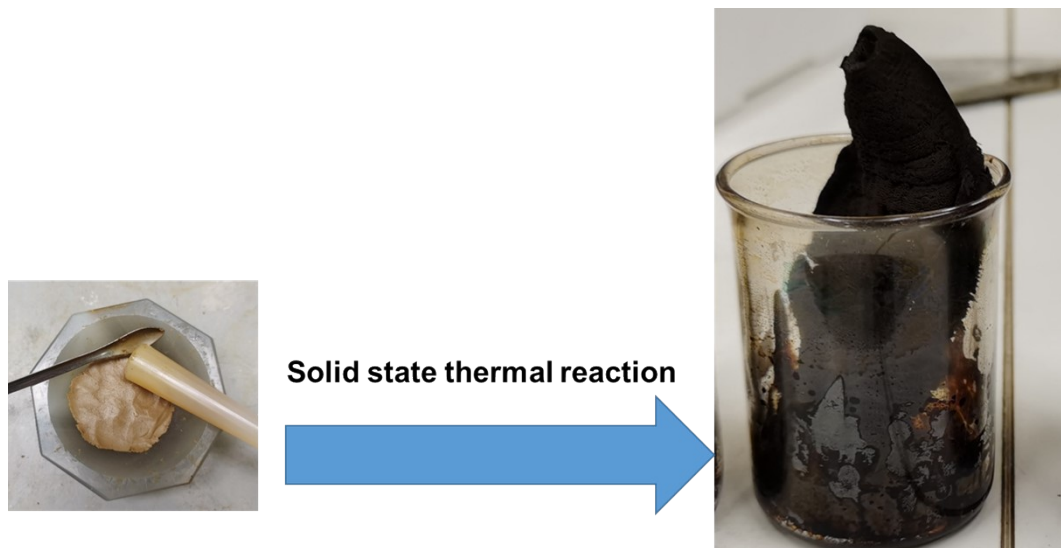


Figure S1. The digital picture of mixed precursor before the solid-state thermal reaction and later.

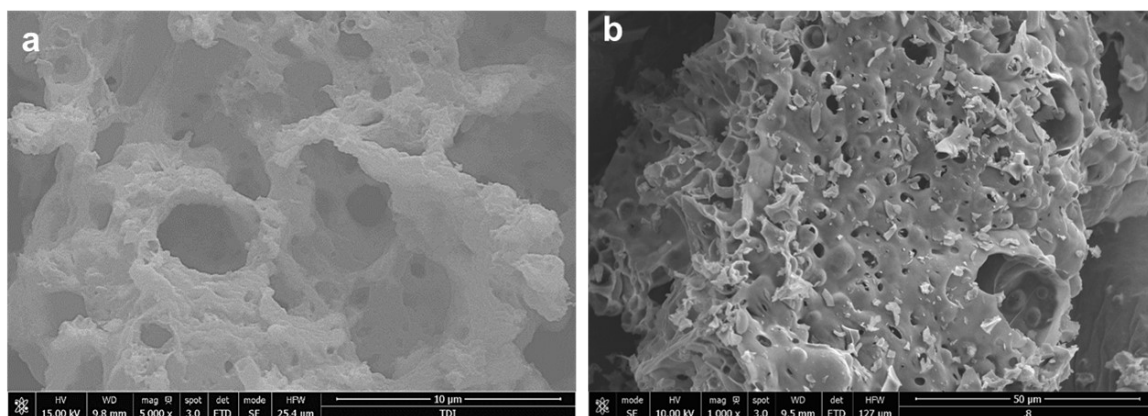


Figure S2. (a) The SEM images of precursor FeCoNiMnCu(1:2) and (b) FeCoNiMnCu-1000(2:1).

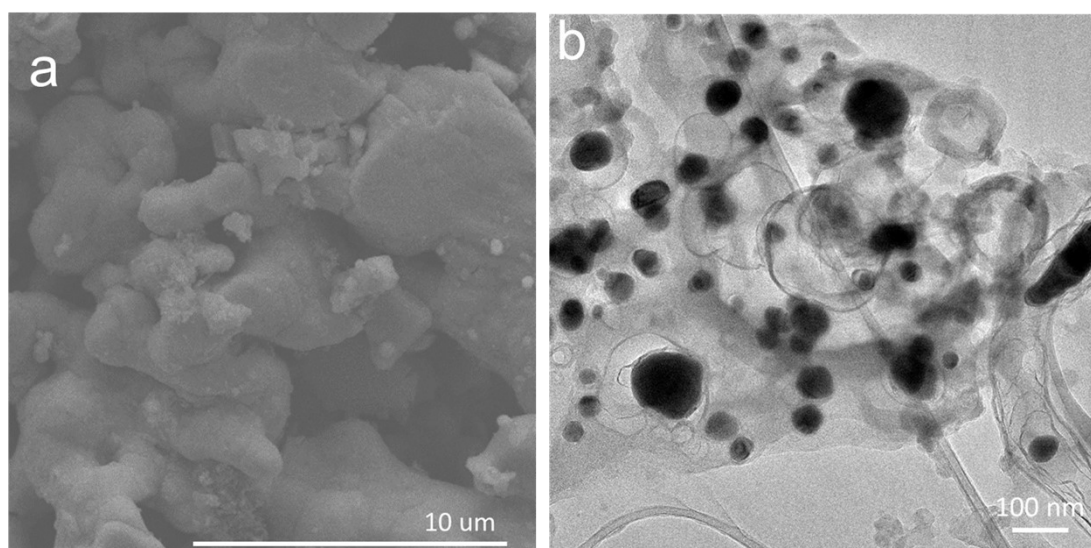


Figure S3. (a) The SEM images of FeCoNiMnCu-900(1:2) and (b) TEM image of FeCoNiMnCu-1000(1:1).

Table S1 The elements mapping data of FeCoNiMnCu-900(1:2).

Elements	Wt%
Co	19.2
Fe	18.1
Ni	16.1
Mn	11.5
Cu	11.9
C	7.6

Table S2 The proportion of each metal in alloys by ICP-MS analysis.

Samples	Mn Content(% in the mass of FeCoNiMnCu)	Fe Content(% in the mass of FeCoNiMnCu)	Co Content(% in the mass of FeCoNiMnCu)	Ni Content(% in the mass of FeCoNiMnCu)	Cu Content(% in the mass of FeCoNiMnCu)	Zn Content in FeCoNiMnCuZn system
FeCoNiMnCu-900(1:1)	4.7	24	23	23	26	2.3
FeCoNiMnCu-1000(1:1)	3.7	24	26	20	27	0.6
FeCoNiMnCu-1100(1:1)	2.8	24	24	23	26	1.2

Table S3 The results of specific surface area and pore volume for prepared catalysts.

Sample	Specific surface area m ² /g	Pore volume cm ³ /g	Micropore volume cm ³ /g
FeCoNiMnCu-900(1:1)	276.25	0.30 cc/g	0.054 cc/g
FeCoNiMnCu-1000(1:1)	489.40	0.36 cc/g	0.109cc/g
FeCoNiMnCu-1100(1:1)	348.69	0.30 cc/g	0.068 cc/g
FeCoNiMnCu-1000(2:1)	505.55	0.30 cc/g	0.199 cc/g
FeCoNiMnCu-900(1:2)	6.09	No	No

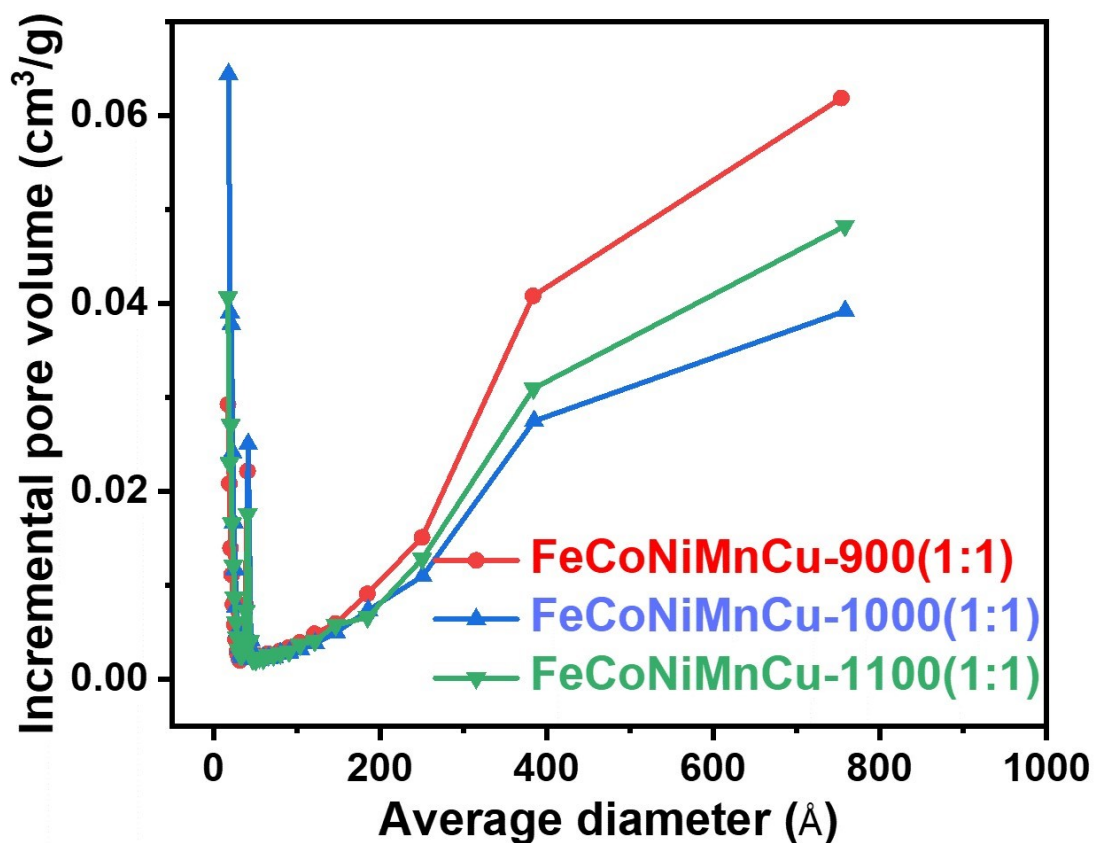


Figure S4 The pore size distribution of FeCoNiMnCu-900(1:1), FeCoNiMnCu-1000(1:1) and FeCoNiMnCu-1100(1:1).

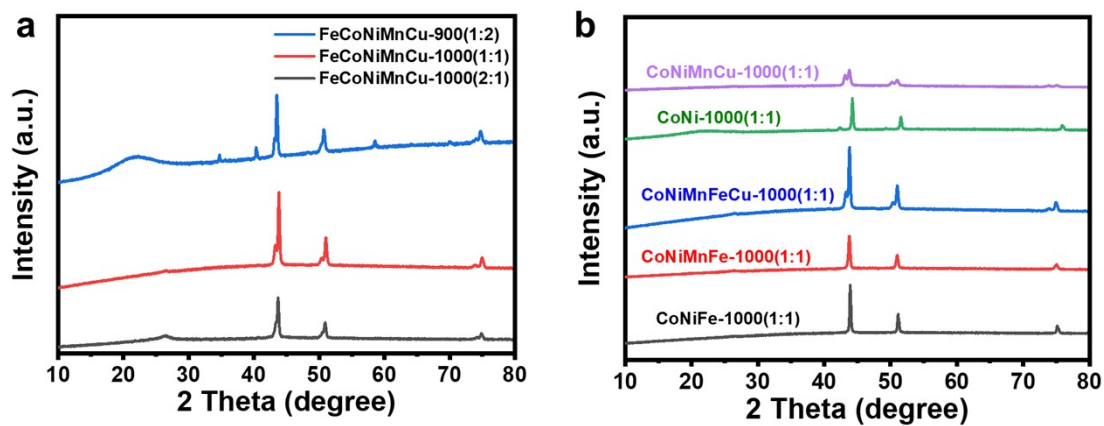


Figure S5 The XRD results of a) FeCoNiMnCu-900(1:2), FeCoNiMnCu-1000(1:1) and FeCoNiMnCu-1000(2:1) b) CoNi-1000(1:1), CoFeNi-1000(1:1), CoFeNiMn-1000(1:1), CoNiMnCu-1000(1:1) and CoFeNiMnCu-1000(1:1).

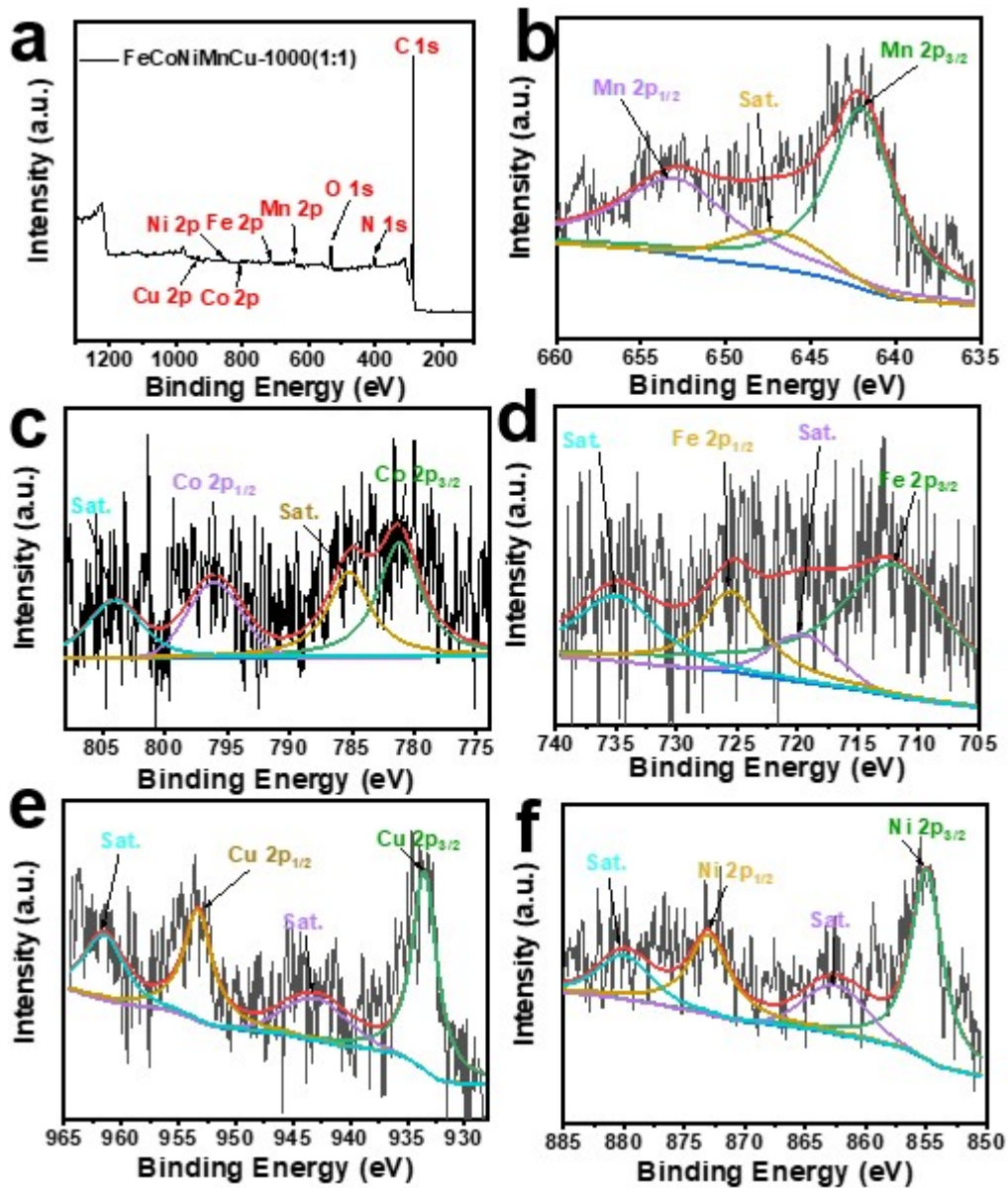


Figure S6 The XPS spectrum of Mn 2p, Fe 2p, Ni 2p, Cu 2p, Co 2p for FeCoNiMnCu-1000(1:1).

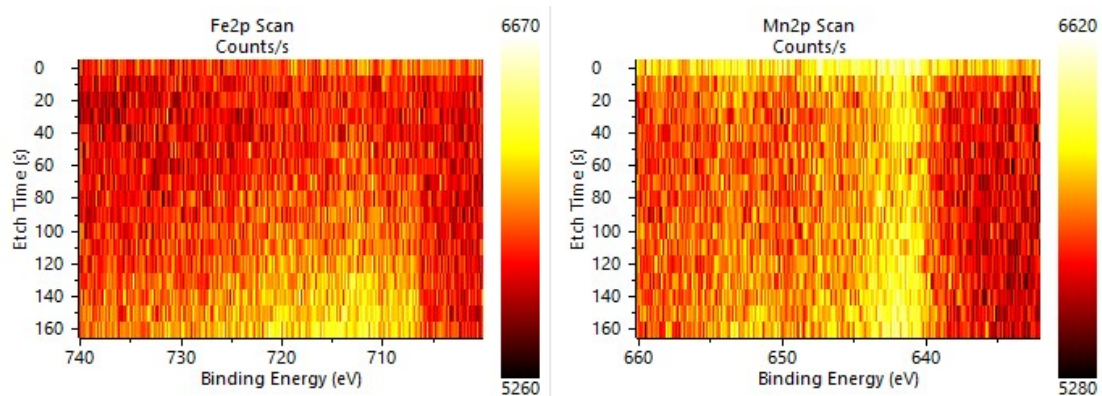


Figure S7 The XPS depth profile of Mn 2p and Fe 2p for FeCoNiMnCu-

1000(1:1)

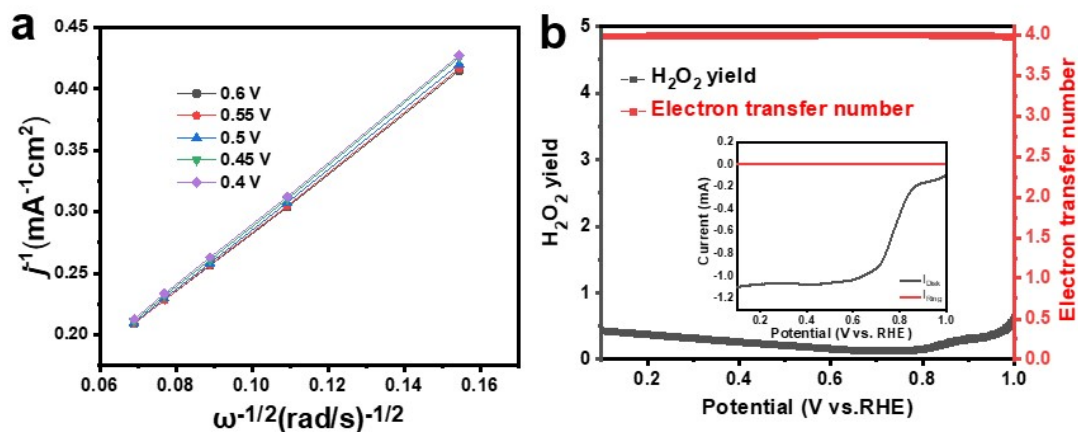


Figure S8 a) the K-L plots and b) the H₂O₂ yield rate and electron transfer number based on the set up of Ring and Disk electrode for FeCoNiMnCu-1000(1:1).

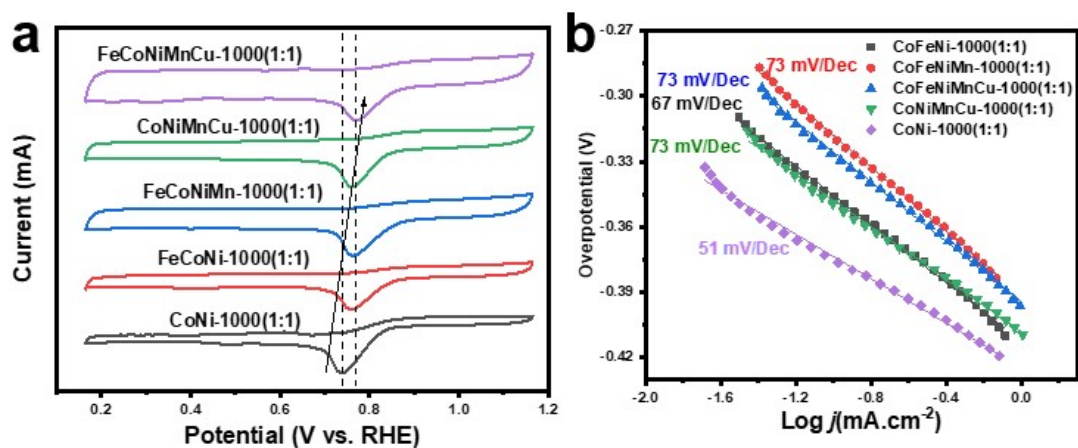


Figure S9. a) The CV curves of the catalysts with the various number of metals in O₂ atmosphere, b) and their corresponded Tafel slope of alloys metal composition.

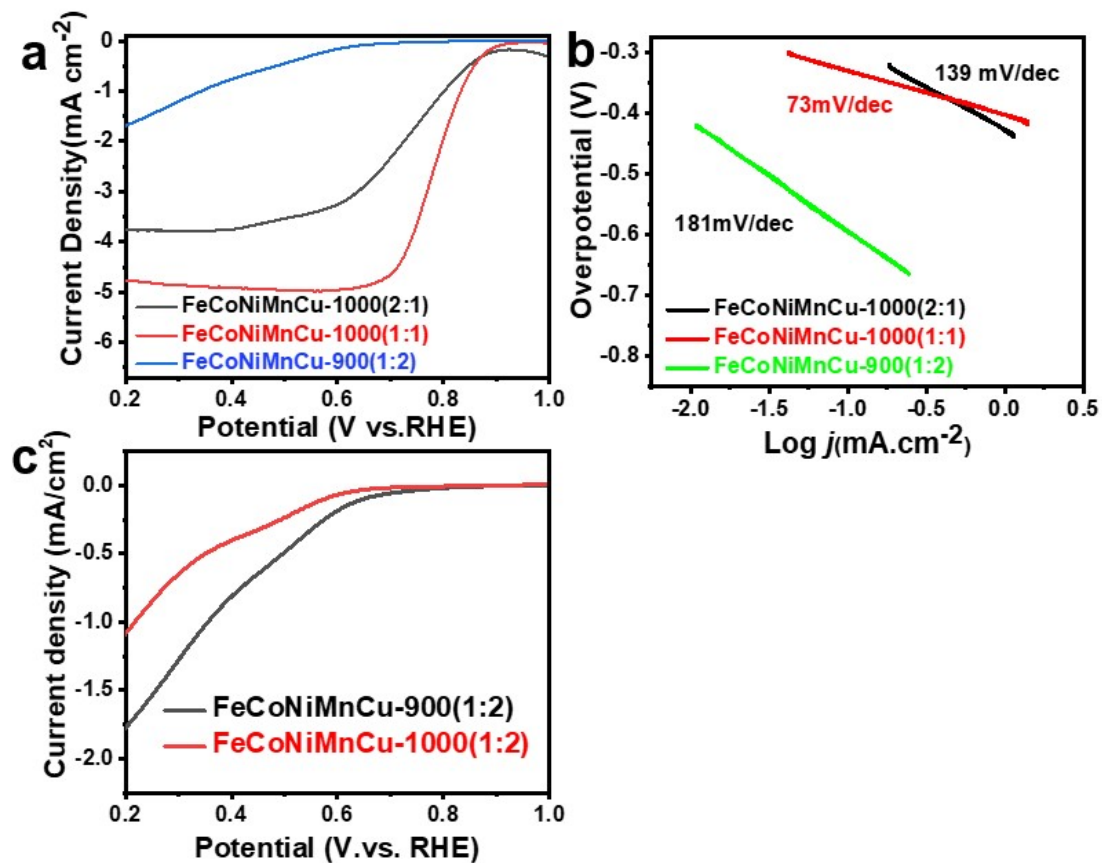


Figure S10 a) LSV curves, b) Tafel slope of the prepared FeCoNiMnCu-1000(2:1), FeCoNiMnCu-1000(1:1), FeCoNiMnCu-900(1:2). c) LSV curves of FeCoNiMnCu-900(1:2) and FeCoNiMnCu-1000(1:2).



Figure S11 the digital picture of FeCoNiMnCu-1000(2:1), FeCoNiMnCu-1000(1:1) and FeCoNiMnCu-900(1:2).

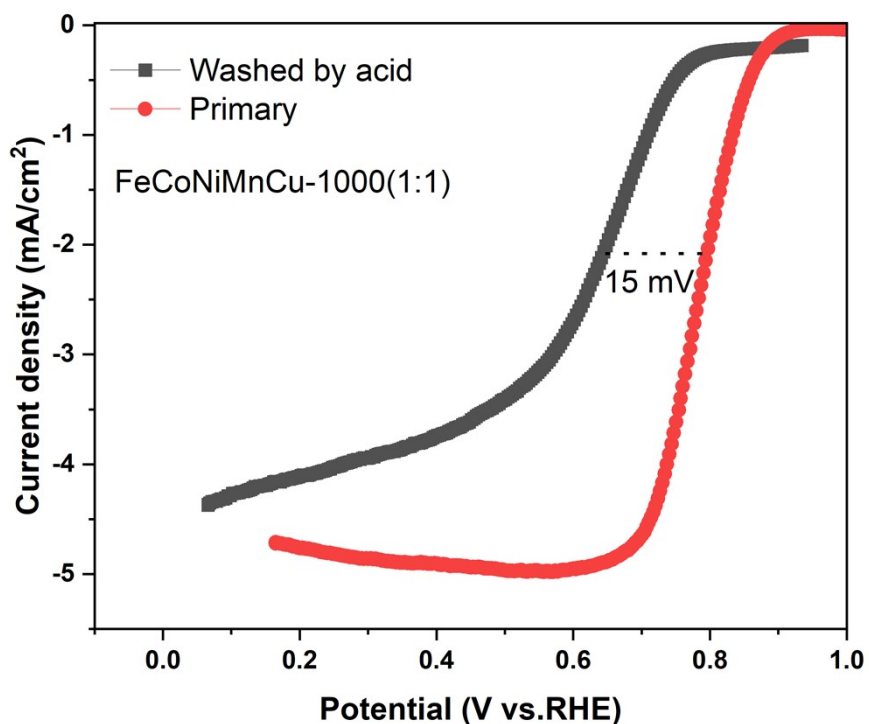


Figure S12. LSV curves of primary and washed by acid FeCoNiMnCu-1000(1:1) catalysts.

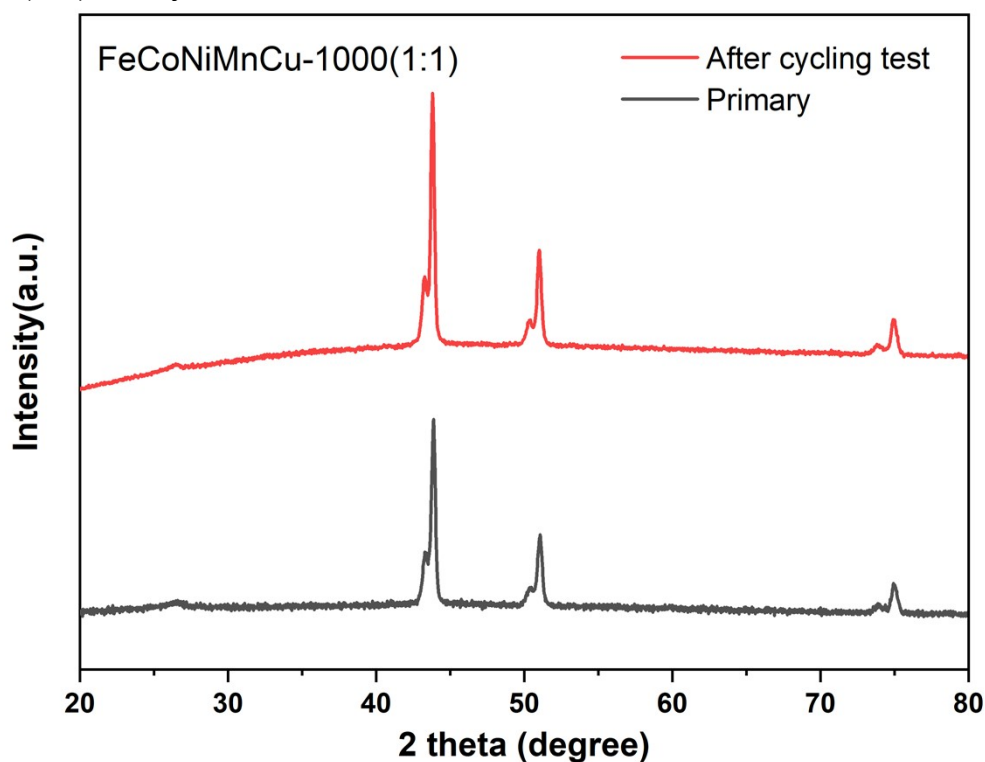


Figure S13 XRD result of primary FeCoNiMnCu-1000 (1:1) and after long time CV test.

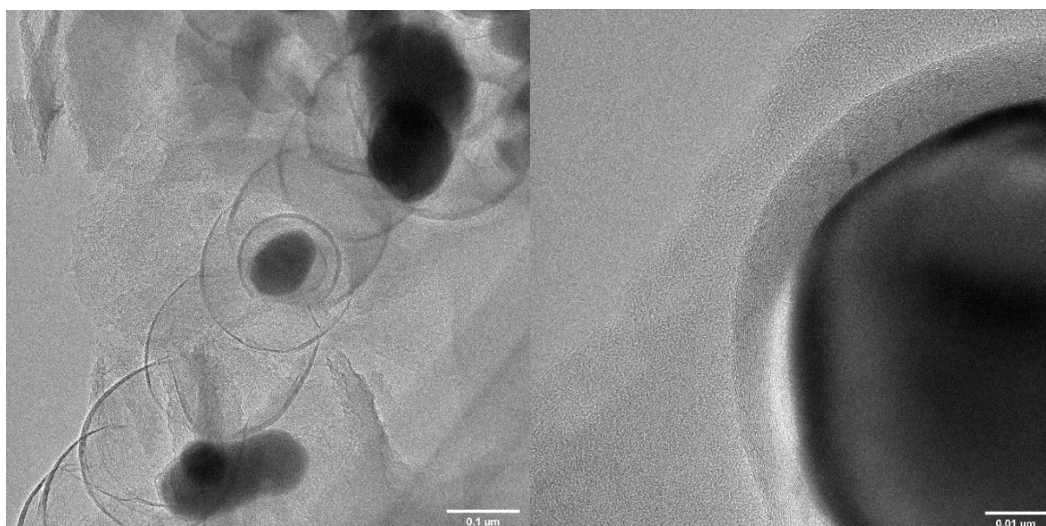


Figure S14 TEM images FeCoNiMnCu-1000 (1:1) after CV test.

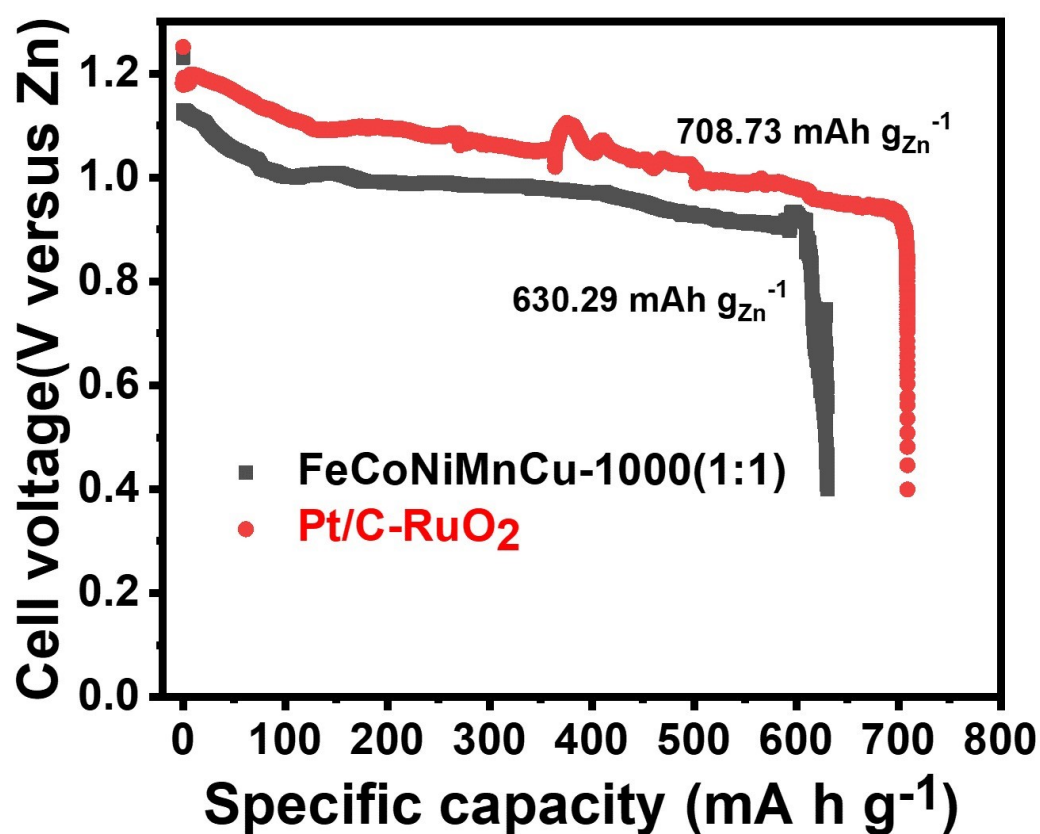


Figure S15 The specific capacity of FeCoNiMnCu-1000(1:1) and 20 wt% Pt/C-RuO₂ based on the zinc consumption.